Stereo Reconstruction

TUM - 3D Scanning & Motion Capture Course

Group 10: Atilla Nalcaci, Benjamin Rickels,
Jiesheng Ding, Siyuan Shen
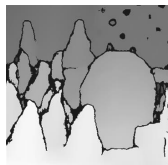
What is Stereo Reconstruction?

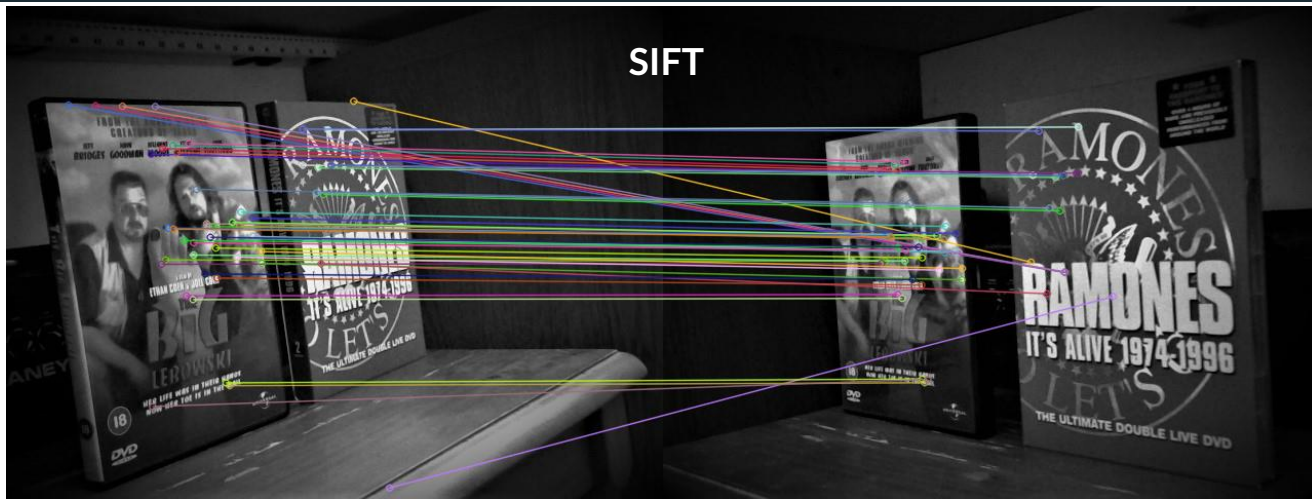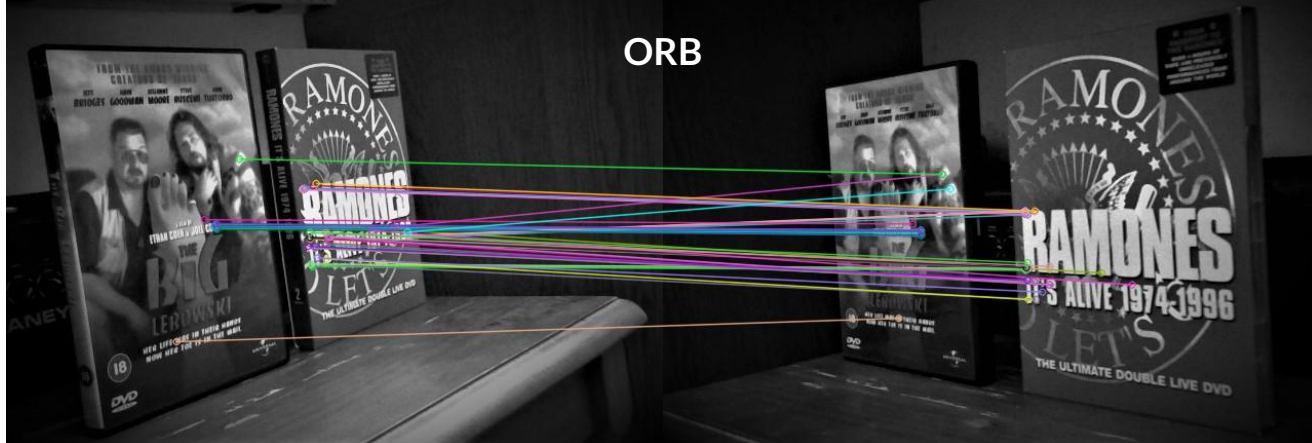left   right

Stereo Pair

Disparity Map

Mesh

Feature Detectors

➢ **S**cale **I**nvariant **F**eature **T**ransform

➢ **O**riented FAST and **R**otated **B**RIEF

SIFT

ORB

Epipolar Geometry

$$\mathbf{x}_R F \mathbf{x}_L \equiv \mathbf{x}_R K^{-T} \hat{T} R K^{-1} \mathbf{x}_L = 0$$

Epipolar Line

X

X_1

X_2

X_3

x_L

x_R

O_L

e_L

R, T

e_R

O_R

Left view

Right view
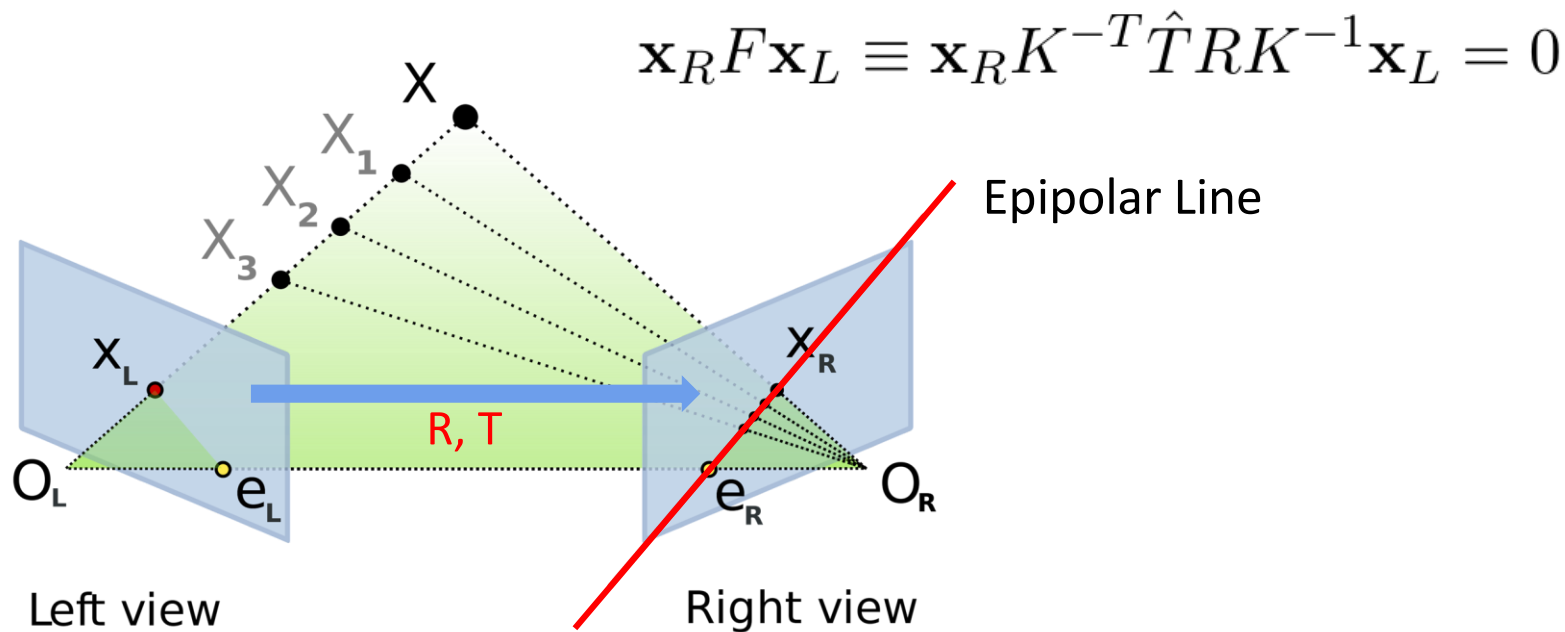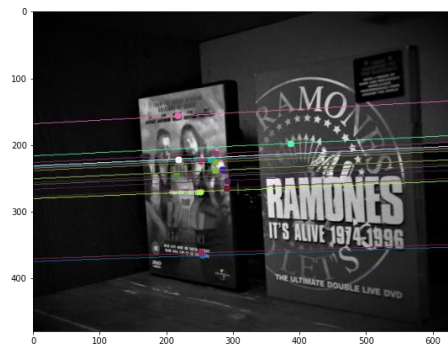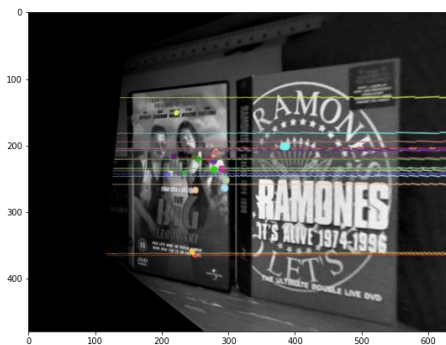
Rectification

Origin

Rectified

Left

Right

Block Matching

➤ Find corresponding block (≙ group of pixels) in left and right image

➤ Motion estimation

➤ Inversely proportional to depth

➤ Estimate depth for every **pixel**

Block Matching Example (1)

left (baseline)   right

Block Matching Example (2)

Block Matching Example (3)

Reprojection to 3D

Perspective Transformation Matrix

$$Q = \begin{bmatrix} 1 & 0 & 0 & -c_x \\ 0 & 1 & 0 & -c_y \\ 0 & 0 & 0 & f \\ 0 & 0 & -1/T_x & (c_x - c'_x)/T_x \end{bmatrix}$$
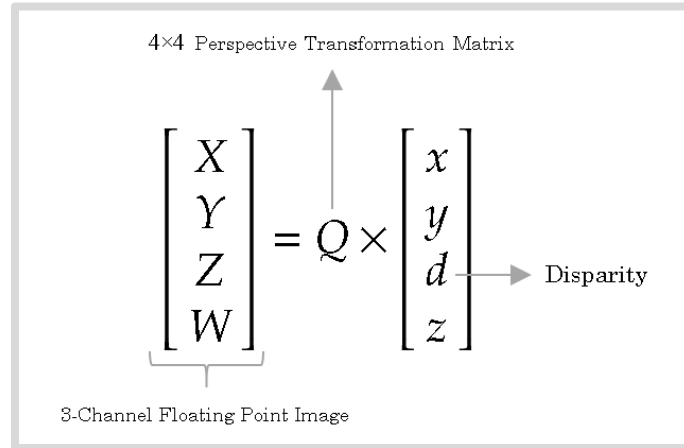
→ Principal Points

→ Focal Length

→ Baseline Length

Defines the relation between 3D points and disparity values in homogeneous coordinate system

Reprojection to 3D

<u>Approach:</u> Transforming a disparity map to a 3-channel image that represents a 3D surface

$$
\underbrace{\begin{bmatrix} X \\ Y \\ Z \\ W \end{bmatrix}}_{\text{3-Channel Floating Point Image}} = Q \times \begin{bmatrix} x \\ y \\ d \\ z \end{bmatrix}
$$

4×4 Perspective Transformation Matrix

Disparity

Above computation is executed for each pixel **(x, y)** and its corresponding disparity **d**
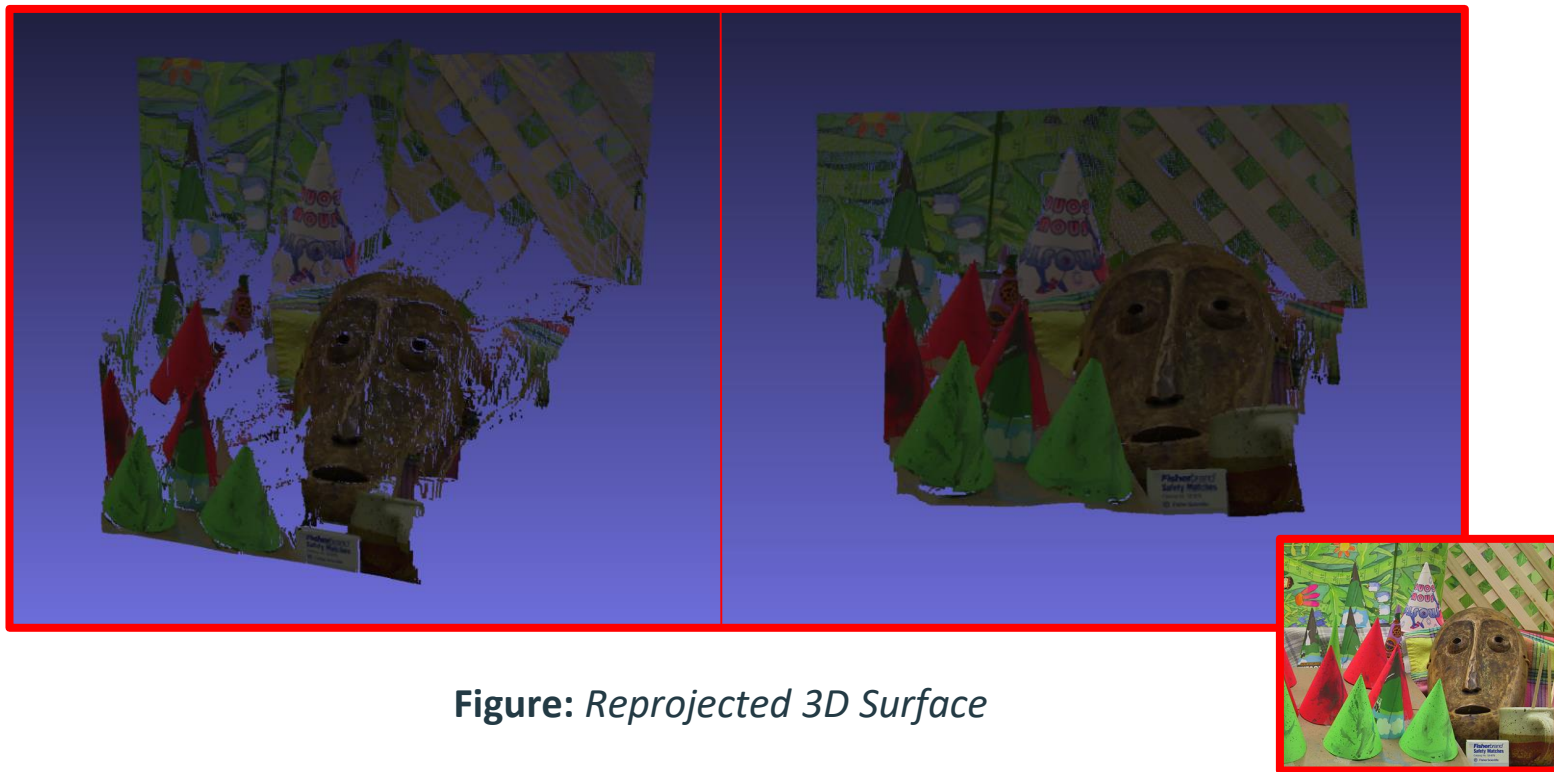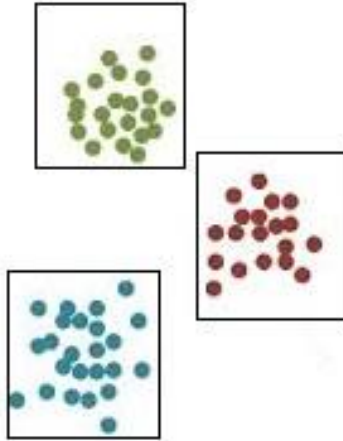
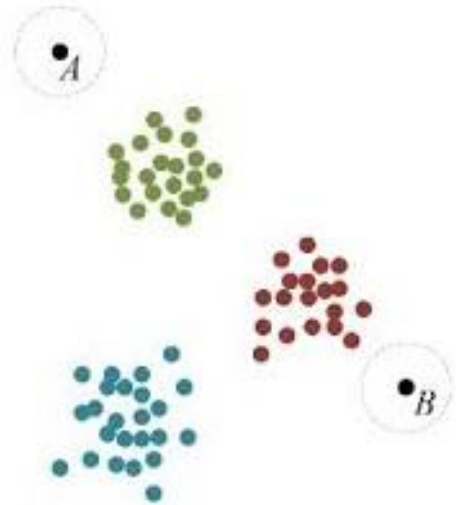# Output

Figure: *Reprojected 3D Surface*

Preparation

➢ Downsampling

➢ Outlier removing

➢ Normal estimation

# Preparation

Downsampling

Outliers

Normal Estimation

➢ Near points (K search/ Radius search)

➢ Plane estimation (Least Square)

➢ Normal computation

Mesh Generation--Greedy Projection Triangulation

➢ 3D points projected to a certain plane through the normal

➢ Delaunay-based spatial region growth algorithm

➢ Return to original 3D points according to the connection from the projection
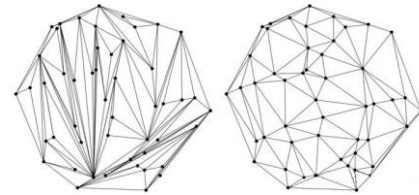
Conclusion

Input: two images from different views

1. Feature points detection and matching

2. Camera motion retrieval and image rectification

3. Disparity map computation

4. Point cloud reprojection

5. Normal estimation and mesh generation

Output: 3D mesh

Thank you!